INVENTORY MANAGEMENT

Inventory: any idle material stored to meet future demand

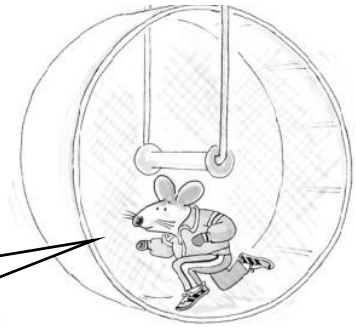
Objective of Inventory Control

To achieve satisfactory levels of customer service while keeping inventory costs within reasonable bounds.

Average Inventory =
(Beginning of Month Inventory + End of Month Inventory)
2

Inventory Costs:
Costs of ordering and carrying inventory (not overstock)

Fill rate:
Level of customer service (not understock)



Inventory turnover: Cost of Goods Sold / Average Inventory Investment

$200,000 COGS / $20,000 Inventory on Hand = 10 Inventory Turns

Topic Exploration

Inventory Management
1. What are some functions of inventory (or why would there be so much more inventory on an organization's balance sheet?)
2. What is 'ABC Analysis,' and how is it implemented?
3. Explain each of the following concepts: 'independent inventory,' dependent inventory,' holding cost,' ordering cost,' and 'setup cost.'
4. Explain each of the following concepts: 'EOQ Model,' POQ Model'

1. What are some functions of inventory (or why would there be so much more inventory on an organization's balance sheet?)

Functions of Inventory

1. To decouple or separate various parts of the production process
2. To decouple the firm from fluctuations in demand and provide a stock of goods that will provide a selection for customers
3. To take advantage of quantity discounts
4. To hedge against inflation
5. Seasonal demand build up
6. Work –in- Process Inventory

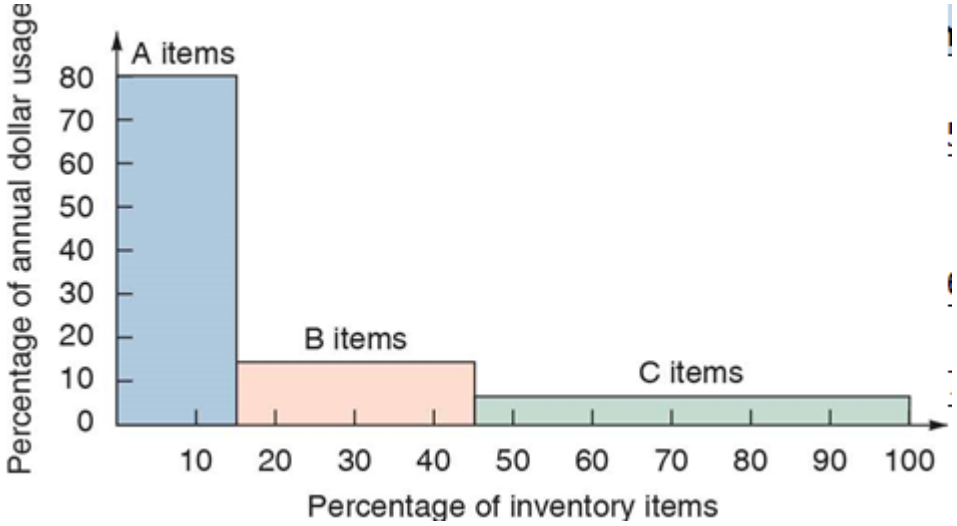
Managing Inventory via ABC CLASSIFICATION/ANALYSIS

- Organization system that divides inventory into three classes, A-B-C, based on criteria:

- Anticipated engineering changes
- Delivery problems
- Quality problems
- High unit cost
- Annual dollar volume
- Other criteria are also possible

Managing Inventory via ABC CLASSIFICATION/ANALYSIS

- Divides inventory into three classes based on annual dollar volume
  - Class A - high annual dollar volume
  - Class B - medium annual dollar volume
  - Class C - low annual dollar volume
- Used to establish policies that focus on the few critical parts and not the many trivial ones



Typical Classification

ITEM	% of SKU	% of AVG $ VALUE
A	15-20 %	70-80 %
B	20-35 %	15-20%
C	50-60 %	5-6 %

Example: A-B-C Classification

Item Number	Annual Demand	Unit Cost
1	600	14.17
2	1,550	17
3	1,000	12.5
4	250	0.6
5	350	42.86
6	1,200	0.42
7	2,000	0.6
8	1,000	$90.00
9	100	8.5
10	500	154

ITEM	% of SKU	% of AVG $ VALUE
A	15-20 %	70-80 %
B	20-35 %	15-20%
C	50-60 %	5-6 %

Example: A-B-C Classification

Item Number	Annual Demand	Unit Cost	Total Cost	% of Total
1	600	14.17	8502	3.66%
2	1,550	17	26350	11.35%
3	1,000	12.5	12500	5.39%
4	250	0.6	150	0.06%
5	350	42.86	15001	6.46%
6	1,200	0.42	504	0.22%
7	2,000	0.6	1200	0.52%
8	1,000	$90.00	90000	38.78%
9	100	8.5	850	0.37%
10	500	154	77000	33.18%
	Total		232057	

ITEM	% of SKU	% of AVG $ VALUE
A	15-20 %	70-80 %
B	20-35 %	15-20%
C	50-60 %	5-6 %

ITEM	% of SKU	% of AVG $ VALUE
A	15-20 %	70-80 %
B	20-35 %	15-20%
C	50-60 %	5-6 %

Example: A-B-C Classification

Item Number	Annual Demand	x	Unit Cost	=	Annual Dollar Volume (ADV)	% of Total ADV	
8	1,000		$ 90.00		$ 90,000	38.8%	
10	500		154.00		77,000	33.2%	
2	1,550		17.00		26,350	11.3%	
5	350		42.86		15,000	6.4%	
3	1,000		12.50		12,500	5.4%	
1	600		14.17		8,500	3.7%	
7	2,000		.60		1,200	.5%	
9	100		8.50		850	.4%	
6	1,200		.42		504	.2%	
4	250		.60		150	.1%	

Total = $232,054

Example: A-B-C Classification

Typical Classification

ITEM	% of SKU	% of AVG $ VALUE
A	15-20 %	70-80 %
B	20-35 %	15-20%
C	50-60 %	5-6 %

Item Number	Annual Demand	x	Unit Cost	=	Annual Dollar Volume (ADV)	% of Total ADV	
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3	1,000		12.50		12,500	5.4%	
1	600		14.17		8,500	3.7%	
7	2,000		.60		1,200	.5%	
9	100		8.50		850	.4%	
6	1,200		.42		504	.2%	
4	250		.60		150	.1%	

A

72%

B

23%

C

5%

Total = $232,054

3. Explain each of the following concepts: 'independent inventory,' dependent inventory,' holding cost,' ordering cost,' and 'setup cost.'

Independent Versus Dependent Demand

- **Independent demand** - the demand for item is independent of the demand for any other item in inventory
- **Dependent demand** - the demand for item is dependent upon the demand for some other item in the inventory

Dependent Demand

Raw materials & purchased parts

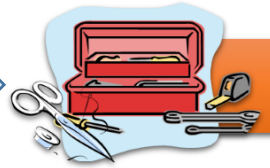
Dependent Demand

Partially completed items called *work in process (WIP)*

Independent Demand

Finished-goods (or merchandise)

Dependent Demand



Spare parts, tools, & supplies

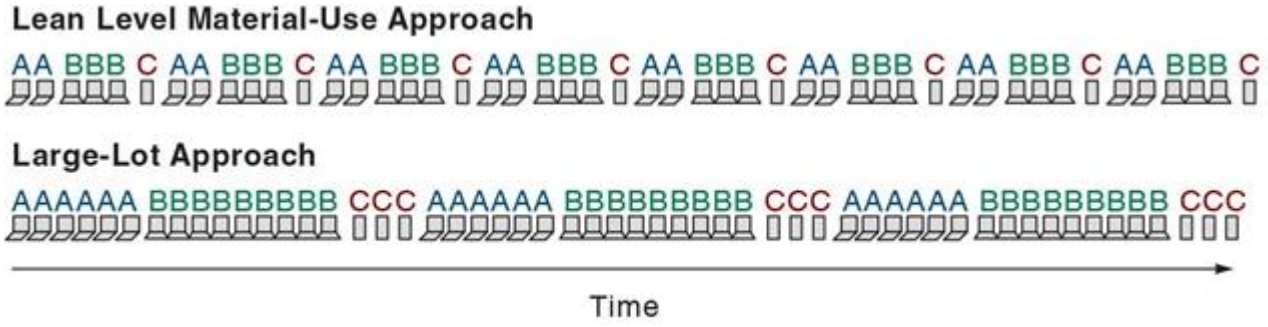
Maintenance/repair/operating (MRO)

Holding, Ordering, Setup Costs (& Shortage Costs)

- **Holding costs** - the costs of holding or "carrying" inventory over time

- **Ordering costs** - the costs of placing an order and receiving goods, costs determining order quantity, preparing purchase orders, and fixed cost portion of receiving, inspection, off-loading and material handling

- **Setup costs** - cost to prepare a machine or process for manufacturing an order


Lean Level Material-Use Approach
AA BBB C AA BBB C AA BBB C AA BBB C AA BBB C AA BBB C AA BBB C AA BBB C
Large-Lot Approach
AAAAAA BBBBBBBBB CCC AAAAAA BBBBBBBBB CCC AAAAAA BBBBBBBBB CCC
Time

- **Shortage costs** - costs when demand exceeds supply; often unrealized profit per unit

Managing Inventory via INVENTORY COUNTING SYSTEMS

Periodic counting

Physical count of items made at periodic intervals

Perpetual (or continual) tracking

Keeps track of removals from and additions to inventory continuously, thus providing current levels of each item

Tracking Inventories & Using Inventory Control Methods

A) Fixed Order Quantity – Reorder Point Model

B) Fixed-Interval – Order Up to Level Model

C) Single Period Model

CONCEPT APPLICATION

4. Explain each of the following concepts: 'EOQ Model,' POQ Model,' and 'Quantity Discount Model.'	3 & 7

Economic Order Quantity (EOQ)
The order size that minimizes total inventory control cost

Fixed Order Quantity/Reorder Point Model:

Determining Economic Order Quantity

1 **Basic Economic Order Quantity (EOQ)**

2 **Economic Production Quantity (EPQ)**

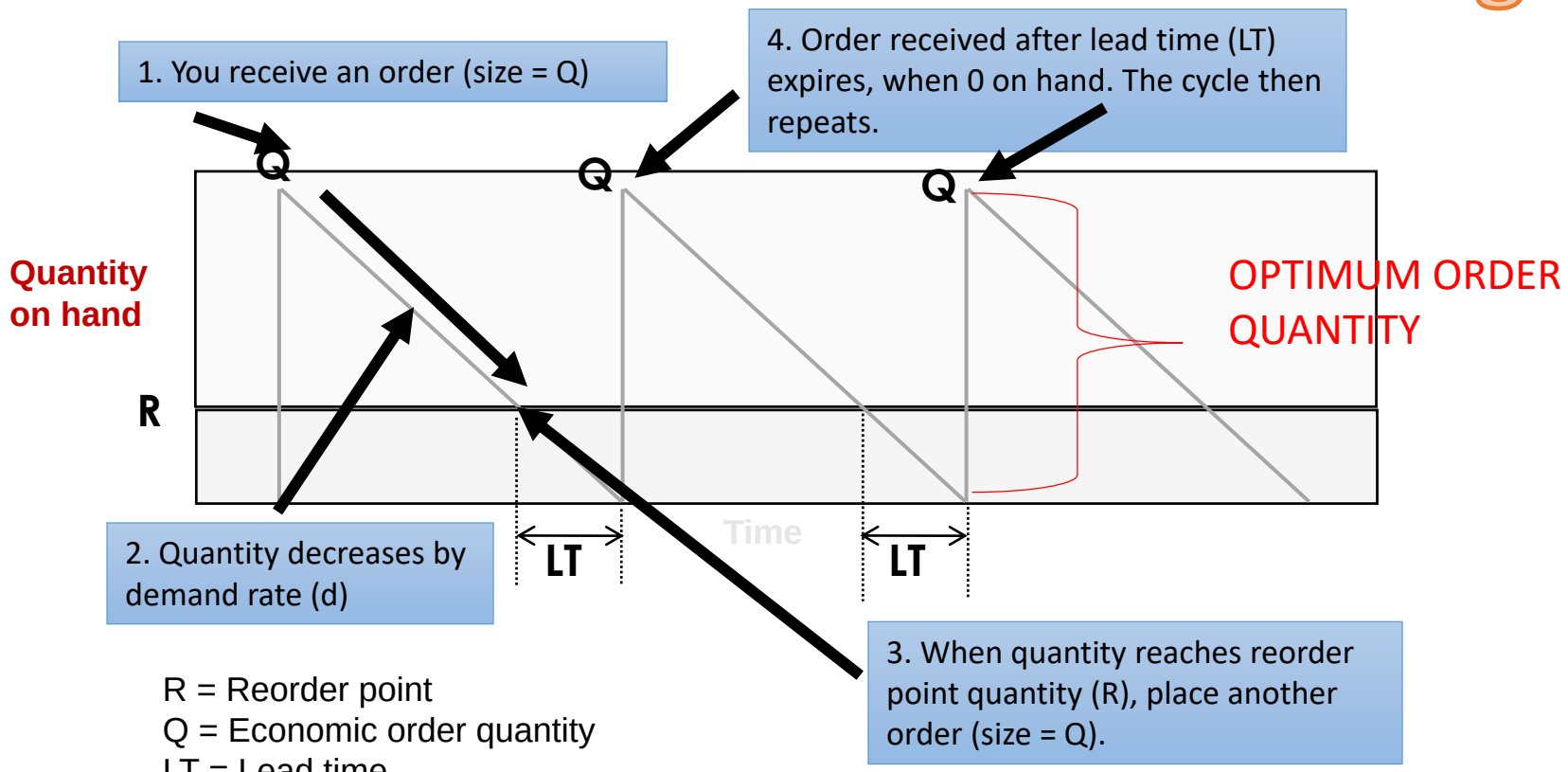
Ordering

Producing

1 Basic Economic Order Quantity (EOQ)

Inventory Cycles with EOQ

Ordering


1. You receive an order (size = Q)
4. Order received after lead time (LT) expires, when 0 on hand. The cycle then repeats.
Q
Q
Q
Quantity on hand
OPTIMUM ORDER QUANTITY
R
Time
LT
LT
2. Quantity decreases by demand rate (d)
3. When quantity reaches reorder point quantity (R), place another order (size = Q).

R = Reorder point
Q = Economic order quantity
LT = Lead time

Basic Economic Order Quantity (EOQ)

Total Annual Cost = Annual Holding Cost + Annual Ordering Cost

$$TC = \frac{Q}{2}H + \frac{D}{Q}S$$

TC = Total annual cost
Q = Order quantity (units)
H = Annual holding cost per unit
D = Annual Demand
S = Ordering (or setup) cost per order
Q_0 = EOQ

Optimum Order Quantity

$$Q_O = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(\text{Annual Demand})\,(\text{Order or Setup Cost})}{\text{Unit Holding Cost}}}$$

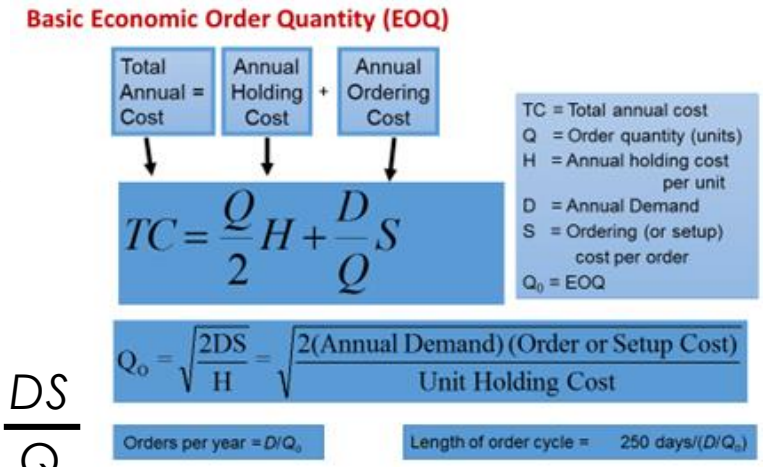
Orders per year = D / Q_o

Length of order cycle = 250 days/(D/Q_o)

Days between 'order placement' and 'order receipt'

EOQ Example 1

A phone company has annual demand of 10,000. A component has annual holding cost of $6 per unit, and ordering cost of $75. Calculate EOQ, Total Cost, number of orders per year and the order cycle time.


Basic Economic Order Quantity (EOQ)
Total Annual = Cost
Annual Holding Cost
+
Annual Ordering Cost
$TC = \frac{Q}{2}H + \frac{D}{Q}S$
TC = Total annual cost
Q = Order quantity (units)
H = Annual holding cost per unit
D = Annual Demand
S = Ordering (or setup) cost per order
Q_o = EOQ
$Q_o = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(\text{Annual Demand})(\text{Order or Setup Cost})}{\text{Unit Holding Cost}}}$
Orders per year = D/Q_o
Length of order cycle = 250 days/(D/Q_o)

H = $6 per unit
S = $75
D = 10,000 units

$$Q_o = \sqrt{\frac{2DS}{H}} \qquad TC = \frac{QH}{2} + \frac{DS}{Q}$$

$$Q_o = \sqrt{\frac{2(10{,}000)\ (75)}{(6)}}$$

Q_o = 500 units

$$TC = \frac{(500)(6)}{2} + \frac{(10{,}000)(75)}{500}$$

TC = $1500 + $1500= $3000

Orders per year = D/Q_o
= 10,000/500
= 20 orders/year

Length of order cycle = 250 days/(D/Q_o)
= 250/20
= 12.5 days

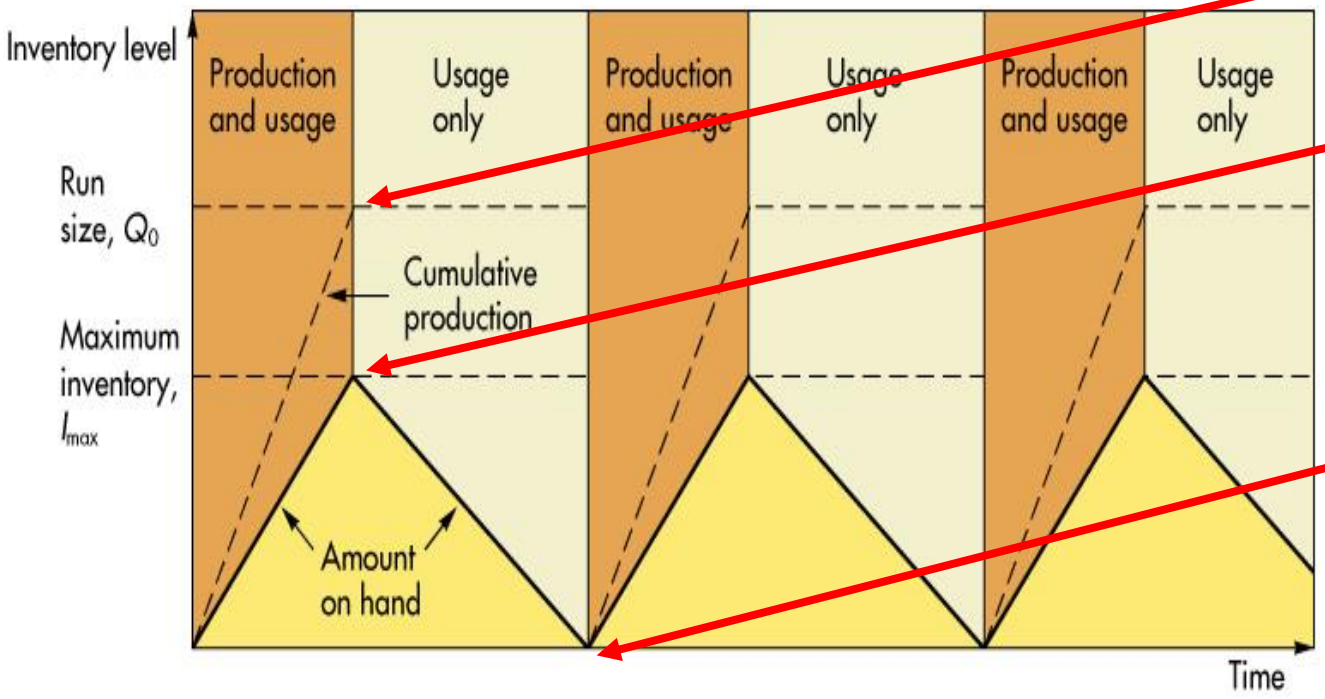
2 Economic Production Quantity (EPQ)

Producing

Economic Production Quantity (EPQ)

Production done in batches or lots

production capacity > usage or demand rate
for a part **for the part**



Maximum level inventory could reach with production only and no depletion

Maximum level inventory could reach with concurrent production and depletion

Replenishment point RESTART PRODUCTION FACTORY

Economic Production Quantity (EPQ)

$$TC = \begin{pmatrix}\text{Annual}\\ \text{Holding}\\ \text{Cost}\end{pmatrix} + \begin{pmatrix}\text{Annual}\\ \text{Setup}\\ \text{Cost}\end{pmatrix} = \left(\frac{I_{\max}}{2}\right)H + \left(\frac{D}{Q}\right)S$$

$$\text{Cycle length} = \frac{Q_0}{d}; \quad \text{Run length} = \frac{Q_0}{p}; \quad I_{\max} = \frac{Q_0}{p}(p-d)$$

TC = Total annual cost
Q = Order quantity (units)
H = Annual holding cost per unit
D = Annual Demand
S = Ordering (or setup) cost per order

$$Q_0 = \sqrt{\frac{2DS}{H}\left(\frac{p}{p-d}\right)}$$

Q_0 = Optimal run or order quantity = **EPQ**
p = Production rate (PER DAY)
d = Usage or demand rate (PER DAY)
I_{max} = Maximum inventory level

EPQ Example

Hold-it Inc. produces reusable shopping bags. Demand is 20,000 bags per day, 5 days per week, 50 weeks per year. Production is 50,000 per day. The setup cost is $200 and the annual holding cost rate is $.55 per bag. **Calculate the EPQ**, the maximum inventory level, the total cost, the cycle length and optimal production run length.

$$TC = \begin{pmatrix}\text{Annual}\\ \text{Holding}\\ \text{Cost}\end{pmatrix} + \begin{pmatrix}\text{Annual}\\ \text{Setup}\\ \text{Cost}\end{pmatrix} = \left(\frac{I_{max}}{2}\right)H + \left(\frac{D}{Q}\right)S$$

$$\text{Cycle length} = \frac{Q_0}{d};\ \text{Run length} = \frac{Q_0}{p};\ I_{max} = \frac{Q_0}{p}(p - d)$$

TC = Total annual cost
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$$Q_0 = \sqrt{\frac{2DS}{H}\left(\frac{p}{p-d}\right)}$$

Q_0 = Optimal run or order quantity = **EPQ**
p = Production rate (PER DAY)
d = Usage or demand rate (PER DAY)
I_{max} = Maximum inventory level

H = $0.55 per bag *S* = $200 *D* = 20,000 bags x 50 wks x 5 days = 5 million
d = 20,000 bags per day *p* = 50,000 bags per day

$$Q_0 = \sqrt{\frac{2(5{,}000{,}000)(200)}{.55}\left(\frac{50{,}000}{50{,}000-20{,}000}\right)} = 77{,}850$$

$$Q_0 = \sqrt{\frac{2DS}{H}\left(\frac{p}{p-d}\right)}$$

OPTIMUM PRODUCTION RUN

EPQ Example

$$TC = \begin{pmatrix}\text{Annual}\\ \text{Holding}\\ \text{Cost}\end{pmatrix} + \begin{pmatrix}\text{Annual}\\ \text{Setup}\\ \text{Cost}\end{pmatrix} = \left(\frac{I_{max}}{2}\right)H + \left(\frac{D}{Q}\right)S$$

$$\text{Cycle length} = \frac{Q_0}{d};\ \text{Run length} = \frac{Q_0}{p};\ I_{max} = \frac{Q_0}{p}(p - d)$$

TC = Total annual cost
Q = Order quantity (units)
H = Annual holding cost per unit
D = Annual Demand
S = Ordering (or setup) cost per order

$$Q_0 = \sqrt{\frac{2DS}{H}\left(\frac{p}{p-d}\right)}$$

Q_0 = Optimal run or order quantity = **EPQ**
p = Production rate (PER DAY)
d = Usage or demand rate (PER DAY)
I_{max} = Maximum inventory level

Hold-it Inc. produces reusable shopping bags. Demand is 20,000 bags per day, 5 days per wk, 50 wks per yr. Production is 50,000 per day. Setup cost is $200 and annual holding cost rate is $.55 per bag. Calculate the EPQ, **the total cost, the maximum inventory level**, the cycle length and optimal production run length.

H = $0.55 per bag *S* = $200 *D* = 20,000 bags x 50 wks x 5 days = 5 mill

d = 20,000 bags per day *p* = 50,000 bags per day

$$TC = \left(\frac{I_{max}}{2}\right)H + \left(\frac{D}{Q}\right)S \qquad I_{max} = \frac{Q}{p} \circ (p - d)$$

$$I_{max} = \frac{77{,}850}{50{,}000}(30000) = 46{,}710 \text{ bags}$$

$$TC = \left(\frac{46{,}710}{2}\right)(.55) + \left(\frac{5{,}000{,}000}{77{,}850}\right)200 = \$25{,}690$$

EPQ Example

Hold-it Inc. produces reusable shopping bags. Demand is 20,000 bags per day, 5 days per week, 50 weeks per year. Production is 50,000 per day. The setup cost is $200 and the annual holding cost rate is $.55 per bag. Calculate the EPQ, the total cost, the maximum inventory level, **the cycle length and optimal production run length.**

$$TC = \begin{pmatrix}\text{Annual}\\ \text{Holding}\\ \text{Cost}\end{pmatrix} + \begin{pmatrix}\text{Annual}\\ \text{Setup}\\ \text{Cost}\end{pmatrix} = \left(\frac{I_{max}}{2}\right)H + \left(\frac{D}{Q}\right)S$$

$$\text{Cycle length} = \frac{Q_0}{d};\ \text{Run length} = \frac{Q_0}{p};\ I_{max} = \frac{Q_0}{p}(p-d)$$

TC = Total annual cost
Q = Order quantity (units)
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p = Production rate (PER DAY)
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I_{max} = Maximum inventory level

$$\text{Cycle length} = \frac{Q}{d};\ \text{Run length} = \frac{Q}{p}$$

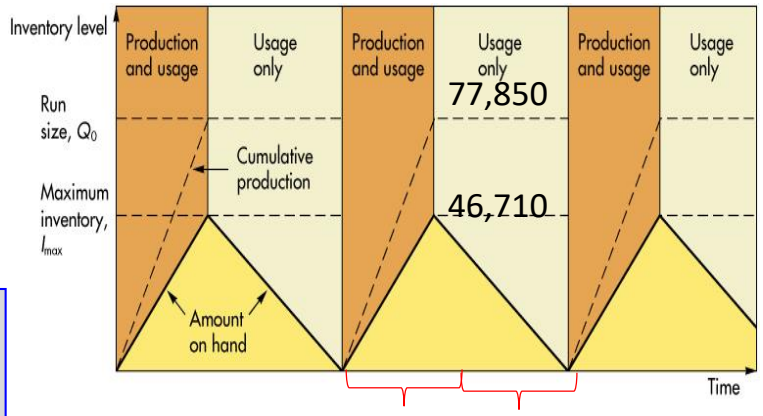
H = $0.55 per bag *S* = $200 *D* = 20,000 bags x 50 wks x 5 days

d = 20,000 bags per day *p* = 50,000 bags per day

$$\text{Cycle length} = \frac{Q}{d};\ \text{Run length} = \frac{Q}{p}$$

$$\text{Cycle length} = \frac{77{,}850}{20{,}000} = \text{every } 3.89 \text{ days}$$

$$\text{Run length} = \frac{77{,}850}{50{,}000} = 1.56 \text{ days per order}$$



1.56 days 2.33 days

3.89 DAYS